MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2015/2016

ETM7156 Mobile Wireless Communications

(M.Eng.Tele (Cyber))

27 February 2016
2.30 p.m. – 5.30 p.m.
(3 Hours)

INSTRUCTION TO STUDENT

1. This examination paper consists of **9 pages** (including the cover page) with **5 questions only**.

2. Each question is worth **20 marks. Attempt ALL questions.**

3. Please write all your answers in the Answer Booklet provided. **Show all relevant steps** to obtain maximum marks.

Question 1 (20 marks)

(a) Describe the three most important small-scale fading effects. [3 marks]

(b) Assume a transmitter power of 1 W at 60 GHz is fed into the antenna with a dimension of 4.6 cm × 3.5 cm. Given that system loss factor is $L = 1$,
(i) Calculate the received signal power at 1 m, 100 m and 1000 m. [5 marks]
(ii) Calculate the free space path loss at above (i) distances. [3 marks]

(c) Find the median path loss using Okumura model for a distance, $d = 50$ km, with a transmitter height, $h_{te} = 100$ m and a receiver height, $h_{re} = 10$ m in a suburban environment. Assuming that the base station transmitter radiates an effective isotropic radiated power (*EIRP*) of 60 dB at a carrier frequency of 900 MHz. (Hint: Refer to Appendices C and D)
[6 marks]

(d) Distinguish between frequency selective fading and flat fading. [3 marks]

Question 2 (20 marks)

(a) In cellular communication systems, prove that for a hexagonal geometry, the co-channel reuse ratio is given by $Q = \sqrt{3N}$, where $N = i^2 + ij + j^2$. (Hint: Use the cosine law ($c^2 = a^2 + b^2 - 2ab\cos\theta$) and the hexagonal cell geometry). [6 marks]

(b) Assume each user of a single base station mobile radio system averages three calls per hour with each call lasting an average of 5 minutes. (Hint: Refer to Apendices A and B)
(i) What is the traffic intensity for each user? [2 marks]
(ii) Find the number of users that could use the system with 1% blocking if only one channel is available. [2 marks]
(iii) Find the number of users that could use the system with 1% blocking if five trunked channels are available. [2 marks]
(iv) If the number of users you found in (iii) is suddenly doubled, what is the new blocking probability of the five channel trunked mobile radio system? Would this be acceptable performance? Justify your answer. [3 marks]

(c) For a system with Pr[*blocking*] = 1% and average call length of two minutes, find the cell capacity due to trunking for 57 channels when switching from omnidirectional antennas to 60° sectored antennas. Assume that blocked calls are cleared and the average per user call rate is 1 call per hour. [5 marks]

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Question 3 (20 marks)

(a) Discuss the tradeoff between power efficiency and bandwidth efficiency of different modulation schemes for mobile wireless communications. Use M-ary phase shift-keying (M-PSK) modulation schemes with $M = 2$ and $M = 16$ as examples in your discussion. [5 marks]

(b) Figure Q3 shows the block diagram of a detection scheme for tracking a slowly fading channel based on pilot symbol transmission. Given the received complex baseband signal of a binary phase-shift keying (BPSK) signal,

$$x(t) = \alpha(t)m(t) + w(t)$$

where $\alpha(t)$ is a complex Rayleigh flat-fading process, $w(t)$ is the channel noise, and

$$m(t) = \sum_k b_k p(t - kT),$$

in which $p(t)$ is the baseband pulse shape, $b_k \in \{\pm 1\}$ are the data symbols, and T is the symbol period.

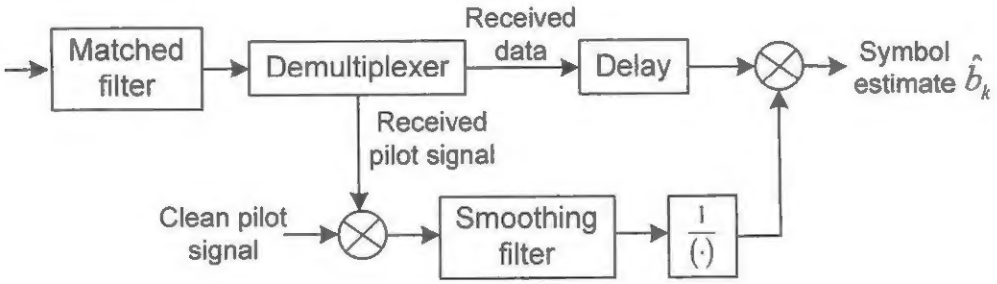

Figure Q3

(i) Briefly describe what is meant by pilot-based communication systems and state the key advantage and disadvantage of such systems. [3 marks]

(ii) Describe with the aid of mathematical equations, how this symbol detection scheme can be used to estimate the slowly fading process $\alpha(t)$ and the symbol b_k. [6 marks]

(c) Briefly describe the working principle and signaling technique used in the Global Positioning System (GPS). [6 marks]

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Question 4 (20 marks)

(a) (i) With the aid of a diagram, describe the training mode and decision-directed mode used in a linear adaptive channel equalizer. [4 marks]

(ii) Draw the block diagram of a digital communication system using an adaptive equalizer at the receiver. Show your block diagram from the baseband message to the reconstructed message data. [6 marks]

(b) Figure Q4 shows one type receiver for detecting code division multiple access (CDMA) signals.

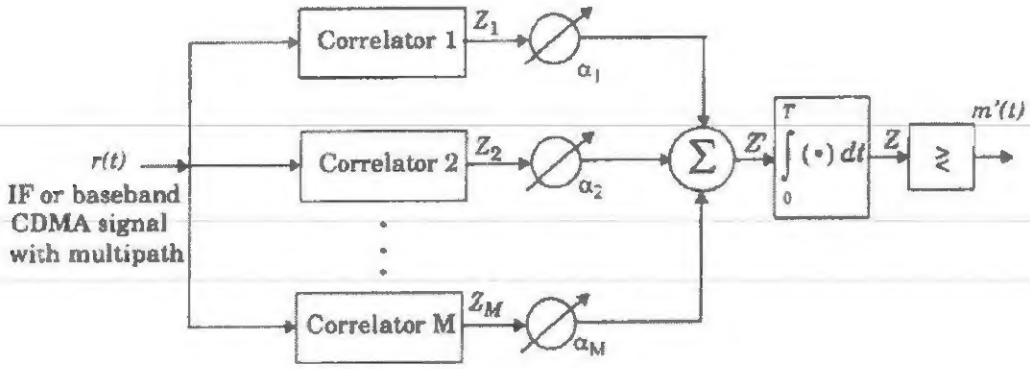

Figure Q4

(i) Name this type of receiver and state the type of diversity exploited by this receiver. [2 marks]

(ii) Briefly describe the working principle of this receiver. [3 marks]

(c) The probability that the signal-to-noise ratio (SNR) of a received signal is less than threshold γ of an M-branch diversity receiver is given by:

$$P_M(\gamma) = 1 - e^{-\gamma/\Gamma} \sum_{k=1}^{M} \frac{(\gamma/\Gamma)^{k-1}}{(k-1)!}$$

where $(k-1)! = \begin{cases} (k-1)(k-2)\cdots 1, & k = 2,3,\ldots \\ 1, & k = 1 \end{cases}$, and Γ is a constant.

We define outage as the situation when the received SNR is less than 15 dB.

(i) Determine the probability of outage when $M = 1$ and $\Gamma = 20$ dB. [2 marks]

(ii) Determine the value of M required if we want to achieve a probability of outage of less than 1% for $\Gamma = 20$ dB. [3 marks]

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Question 5 (20 marks)

(a) With the assistance of illustration, explain how the orthogonal frequency division multiplexing (OFDM) is more spectrally efficient than the frequecny division multiplexing (FDM). [4 marks]

(b) Discuss the working principle of code division multiple access (CDMA). List one advantage and one disadvantage of the CDMA technique. [3+2 marks]

(c) A Global System for Mobile (GSM) employs time division multiple access (TDMA) and a frequency division duplex (FDD). The GSM uses a frame structure where each frame consists of eight time slots. Each time slot in the GSM consists of 6 trailing bits, 8.25 guard bits, 26 training bits and two traffic bursts of 58 bits of data. The data is transmitted at 270.833 kbps.

(i) Determine the number of bits in a time slot. [2 marks]
(ii) Determine the time duration of a bit. [2 marks]
(iii) Determine the time duration of a slot. [2 marks]
(iv) Determine the time duration of a frame. [2 marks]
(v) Find the frame efficiency. [3 marks]

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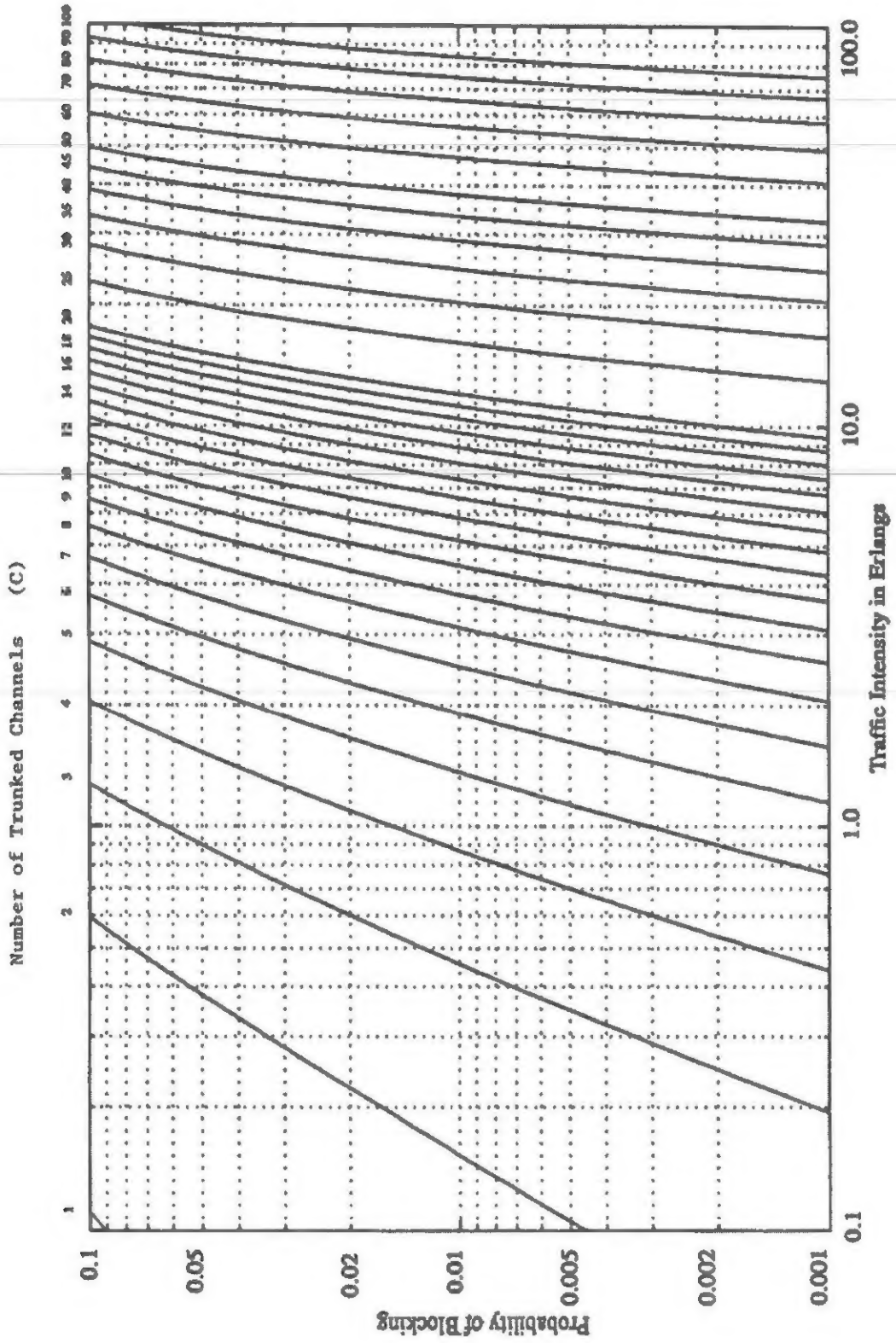
APPENDIX A: The Erlang B chart showing the probability of blocking as functions of the number of channels and traffic intensity in Erlangs.



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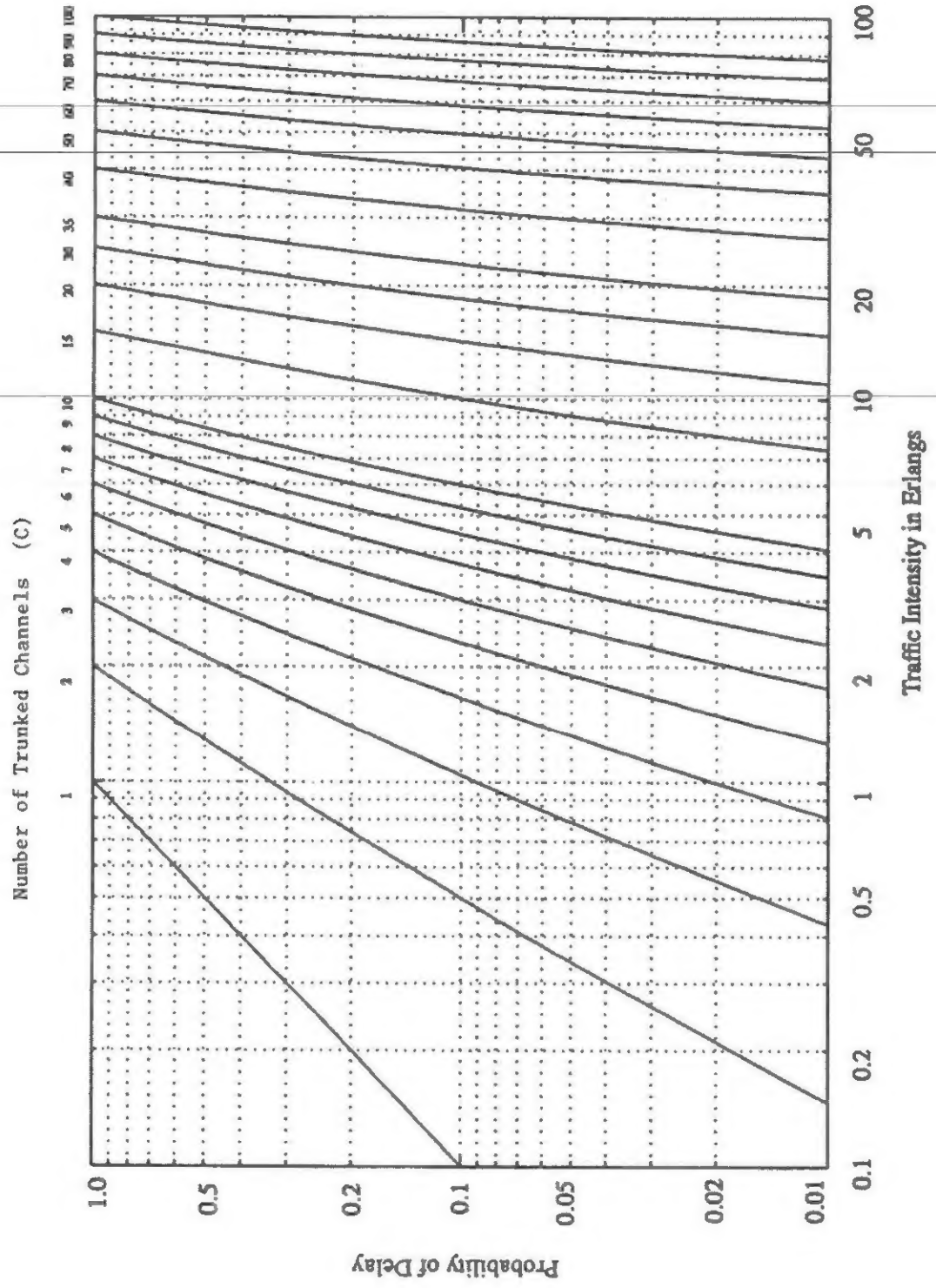
APPENDIX B: The Erlang C chart showing the probability of a call being delayed as a function of the number of channels and traffic intensity in Erlangs.



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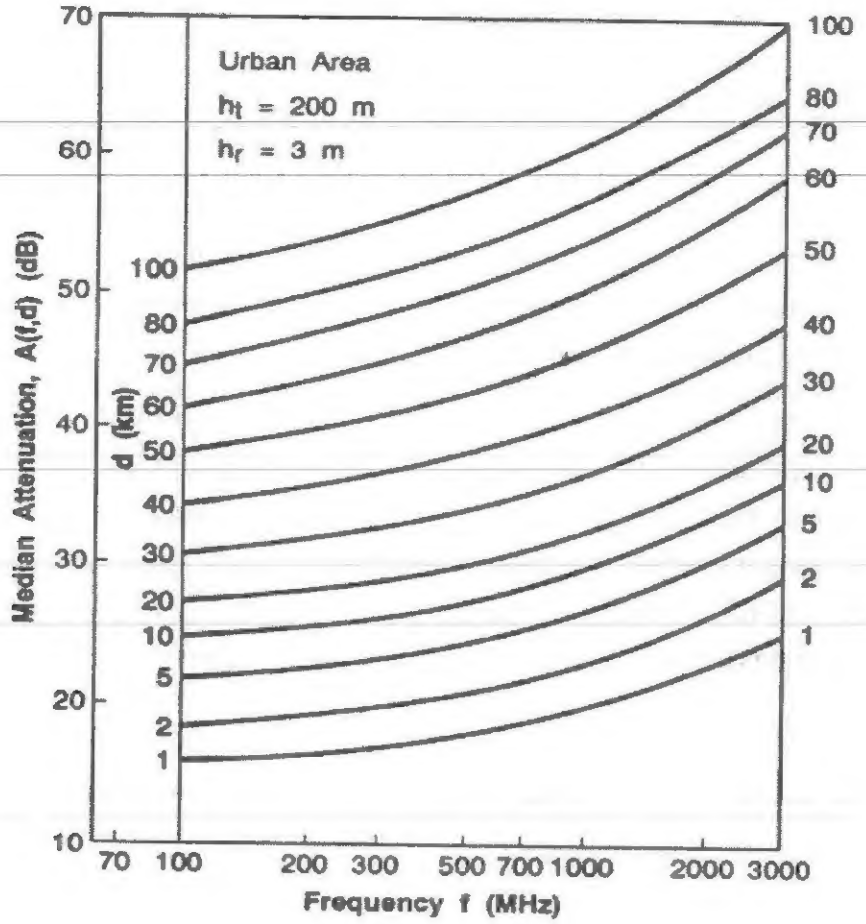
APPENDIX C: Median attenuation relative to free space ($A_{mu}(f,d)$), over quasi-smooth terrain



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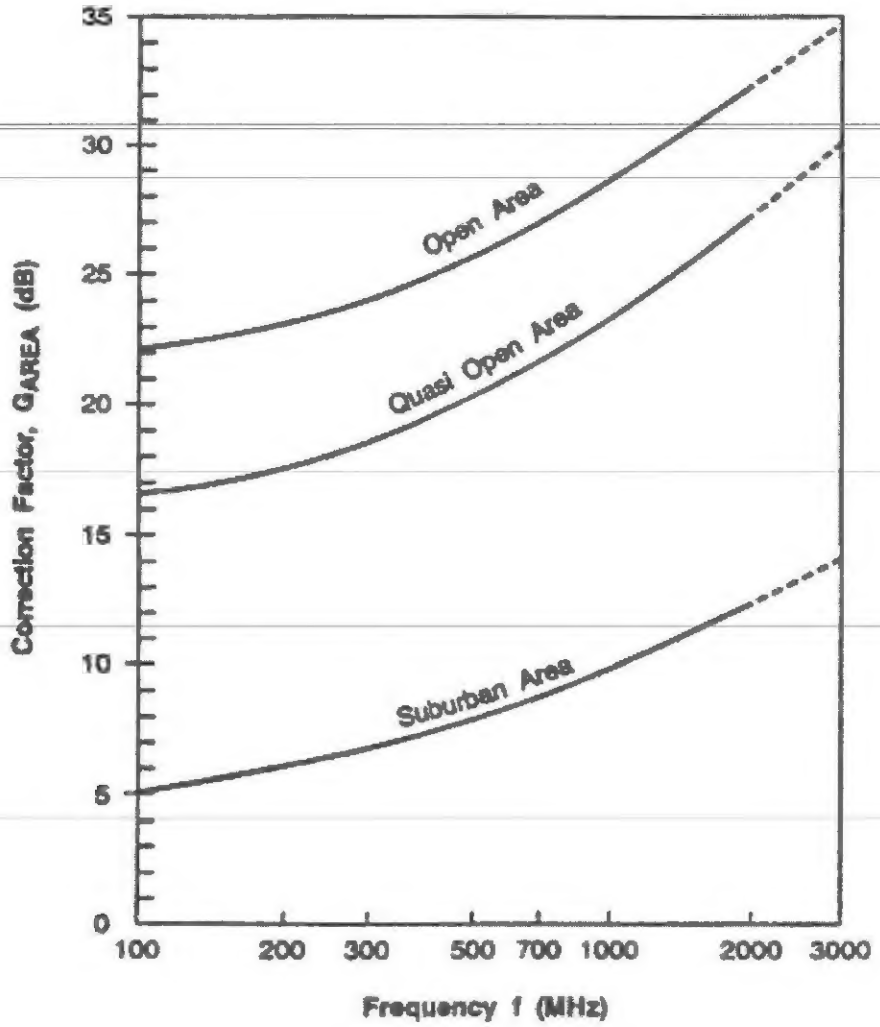
APPENDIX D: Correction factor, G_{AREA}, for different types of terrain



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